Probable Eocene Glacial Deposits in the Fort Apache Region, Arizona.[1]

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When the writer wrote his geology of the Fort Apache region, Arizona, much uncemented gravel and bowlders were found capping the mesas and underlying the lava flows. These deposits he placed in the Tertiary and Quaternary. In his section at Canyon creek, Arizona, from the source of that stream to its confluence with Salt river, he gives 125 feet of coarse, uncemented gravel of gneiss and quartzite bowlders capping the clastic rocks. Gilbert's section at the crossing of Canyon creek in that region, which he copies, also gives 20 feet of coarse, uncemented gravel of quartzite and gneiss bowlders.[2] Some of the writer's other sections in that region are here copied in whole or in part to show the existence of this material in the various parts of the reservation, as follows:[3]

Section in Seven-mile Hill canyon, five miles southeast of Fort Apache, Ariz.

		Feet.
1.	Basalt	200
2.	Volcanic ashes	10
3.	Strata of mostly unlithified sands and clays	40
4.	Shale, light colored, sandy	4
5.	Conglomerate rock, the cement being volcanic ash, the pebbles and cobblestones of this series being quartzite, granite, andesite, rhyolite, limestone of the Paleozoic era, etc. (no cobblestones or pebbles of the basaltic type was found in this conglomerate).	
6.	Strata of partly lithified, coarse-grained, reddish to light brown sandstone, composed of angular and rounded grains of granite, rhyolite, etc. In this series the rhyolite-trachyte particles predominate	60
7.	Carboniferous, red gypsiferous shales, with sandstone and limestone	800
	Total	1,314

Section along east wall of Cherry Creek canyon, Arizona, seven miles north of Salt river, near Mr. James Hinton's house:

		Feet.
1.	Light to dark-brown rhyolite	30
2.	Conglomerate rock	80
3.	Tufa agglomerate	20
4.	Light-gray sandstone	10
5.	Rhyolite	30
6.	Gray sandstone and conglomerate	100
7.	Fine-grained, gray to brown sandstone, composed of ground-up Archæan and Paleozoic rocks, granite, rhyolites, diabases, etc	40
	Total	210

1. For references on this region the reader is referred to the following:
G. K. Gilbert and A. R. Marvin; U. S. Geog. Sur. West of the 100th Meridian, Vol. 111, and special references as follows: Gilbert, pp. 163, 164, 165, 526-528; Marvin, pp. 221-223.
Oscar Loew, ibid., pp. 587, 642.
Albert B. Reagan; Geology of the Fort Apache region in Arizona: Am. Geologist, Nov. 1903, pp. 265-308, 2 maps, 1 plate.

2. Gilbert, ibid., p. 164; Reagan, loc. cit., p. 270.

3. Reagan, ibid., pp. 270-275.

Apparently all Tertiary.

Section south of White river, three miles west of Fort Apache:

		Feet.
1.	Basalt	200
2.	Unlithified volcanic ashes	10
3.	Loose strata of slightly litified clays and sands	40
4.	Carboniferous, red gypsiferous shales with sandstone and limestone	1,000
	Total	1,250

Generalized section on the government trail from Ellison's to Canyon creek:

		Feet.
1.	Adobe clay	8
2.	Loose cobblestones and pebbles	1
3.	Yellow clay interstratified with loose sand	4
4.	Cobblestone stratum	1
5.	Light yellow to pink, lithified, stratified rock, composed of fine grains of Archæan and Tonto rocks	10
6.	Dark-brown, partly lithified sandstone	1
7.	Yellow to brown and pink cross-bedded sandstone	10
8.	Conglomerate series	20
9.	Porphyry, gneiss and granite rocks (intrusive)	100
10.	Tonto sandstone and shale	500
11.	Archæan (?) hornblende biotite granite, olivine diabase and hornblendic diorite	500
	Total	1,155

Section on Carrixo creek (after Gilbert):[4]

		Feet.
1.	Coarse gravel composed of vitreous sandstone quartzite and gneiss bowlders	50
2–7.	Clastic rocks	1,370
	Total	1,420

Section north from near Camp Apache (Fort Apache) (after Gilbert):[5]

		Feet.
1.	Basalt and basalt gravel	70
2.	Pale pink slightly coherent, massive sand and gravel resting unconformably on No. 3	520
3–6.	Clastic rocks	1,670
	Total	2,260

It is quite possible from the data at hand that the deposits have accumulated in Seven-mile Hill section and in the Salt river and Hinton regions and in many other places in the area covered by the paper throughout the Tertiary, and may have begun even earlier. A part of the series which the writer had originally designated Tertiary, principally in the sections mentioned above, begins with a consolidated, coarse, conglomerate stratum, beneath which are strata of partly lithified sands, clays and gravels reaching a thickness of nearly a thousand feet in thickness in some places. The formation is found, for the most part, in the ancient canyons of the region. Conformably on the formation above designated Tertiary in this paper, and in my original report on the region, are hundreds of feet of unconsolidated gravels and clays, and occasionally volcanic ashes. This series covered the entire region, excepting, possibly, the Ellison dome, so that the lava flows which closed the Quaternary flowed

4. Gilbert, loco cit.; Reagan, ibid., p. 274.

5. Gilbert, ibid., p. 165.

over a plain. Since then much has been removed, so that now it is patchy, except where it is protected by superimposed lava. It now fills the valleys of the Pinal and Apache mountain districts, the volcanic and plutonic rocks projecting above it as peaks and mountains. The middle Cherry Creek valley and the Tonto basin, as well as the Ellison flat, are covered with it. It covers the Mogollon mesa, together with its southern prolongations, including the Cibicu divide, to a thickness from 500 to 1,000 feet in many places. It is the surface rock of much of the Kelley butte country, and extends beneath the lava of the Nanatan plateau as far as visited.

At the time of the writer's studying the region he believed that these deposits were due to a laking stage, due to differential uplift and lava flows, as he found no striæ markings; but since his study of the glaciation in the San Juan mountains in Colorado and the Deep creek region, Utah, he has been compelled to change his views and conclude that the deposits in question are of glacial origin and caused probably in part by laking, due to glaciation and volcanic disturbances. This view is also borne out by the fact that the Cibicu divide and the Mogollon mesa, which are both heavily covered with this drift, are higher than the surrounding country and show no evidence of a laked stage.

The deposits, clays, sands, gravels and boulders of schists, quartzites, gneisses, carboniferous rocks, vitreous Tonto sandstone, diorite, trachytes and Archæan rocks indicate different development centers of the glaciers that swept over the region. The material of the Seven-mile Hill deposits and that beneath the lava flows of the Nanatan plateau indicate that they came from the White mountains to the eastward, as do also the depositing dip of the clays and sands. But the deposits of the Cibicu divide indicate by their composition that they came from the west and northwest, as do also the Hinton and Salt river deposits, being composed of quartzites, gneiss, vitreous Tonto sandstone, Archæan and Paleozoic rocks and biotite granite, all of which are exposed in the upper Canyon creek region, the Ellison dome and the Tonto basin. It is also quite probable that some of the debris came from the mountains to the northward.

From the inadequate data at hand it would seem that at least the deposits below the partly consolidated conglomerate series are Tertiary, extending to the early Tertiary, as Gilbert, Marvin and the writer concluded when examining the region, and the remainder Quaternary, as was then concluded. This being the case as the facts at hand seem to indicate, we would, therefore, have glaciation here in early Tertiary times, probably in the Eocene period, repeated again in the Quaternary. Laking in consequence of blocking lava flows and faulting, probably played its part, as did also the subsequent development of drainage, which is in part inverted and in part diverted.

As a closing remark: The finding of glacial material forming the opening series of the Eocene in many parts of the world brings again to the fore the fact, with emphasis, that glacial epochs have occurred at the beginning (or the close) of each of the great eras of geologic time.[6] This brings up the question again, Why do geologic eras close? Is it not a cosmic cause? And, as the writer has suggested in previous publications, may not these changes,

6. See Atwood; Eocene glacial deposits in southwestern Colorado: Professional Paper 95, B, 1915, pp. 13-26.

both in climate and in readjusting and rebuilding of the earth's crust, be due to causes brought about by our solar system having reached one or the other termini of the great ellipse around which he is whirling his company of planets, meteors, planetoids, secondary planets and comets, as our extreme yearly seasons are caused by similar positions of the earth with reference to the path it travels around the sun.[7]

Glacial Deposits in Pine River Valley, Colorado.

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The table flats at Florida, east of Durango, Colo., on the Denver & Rio Grande railway, on east across Pine river to beyond Spring creek, at La Boca, on that railroad—in fact, the whole area from the bluff mesas west of Durango to the bluff mesas beyond Spring creek to the eastward, in a curve running to the northeast of Durango, bending far to the southward and southeastward—is covered heavily with glacial drift, though the country rocks project above it in points, ridges and buttes in many places. The mesas southwest of Ignacio are also covered with glacial boulders and other glacial material. How much farther the glacier extended is unknown to the writer.

A little northeast of Durango, in the Animas valley, there are heavy morainic deposits,[1] associated with extensive outwash deposits. The same phenomenon appears on the Florida above and in the vicinity of the station of the same name. At Oxford the outwash material, loess, etc., is ten feet deep, superimposed on a bed of boulders often from ten to twenty feet in depth. West of Ignacio the outwash material butts up against the mesas, being often twenty feet thick in the valleys. At Ignacio and at the Southern Ute boarding school, a mile to the northward, the outwash upper till-loess-adobe clay is from five to ten feet deep back from the mesa's edge of the first bench. Immediately underneath this is from five to twenty-five feet of boulders, underlain in places with lower till. At La Boca only outwash material was seen, there often forty feet thick as is shown in the valley cuts of the present washes. Three miles north of the present Indian school on Pine river the stream has cut completely through the debris, which here shows no lower till, but twenty-five feet of boulders, on which is superimposed outwash till and loess. The bench west of the Indian boarding school, to which a part of the school lands extend, is 100 feet above Pine river in elevation, but at no place in the slopes from the river to its crest was the original rock shown. On top of the bench is five feet of adobe, beneath which is twenty-five feet of boulders, beneath which is till to an unknown thickness. At Bayfield, ten miles north of Ignacio, the outwash material is of immense thickness, overlying boulders, while to the southeast of that city, over a small ridge of jutting country rock buttes, is a pocket of glacial deposits of a similar nature. Also from Bayfield northward on Pine river for many miles outwash material is very conspicuous; the valley fillings seem to be composed wholly of it.

The glaciers that made these deposits seemed to have two or more centers.

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7. Reagan; Causes of the glacial period: Trans. Kansas Acad. Sci; and Sunspot, vol. 1, No. 11, pp. 13-30; January, 1916.

1. See Atwood; Prof. Paper 95, B, pp. 14, 15.